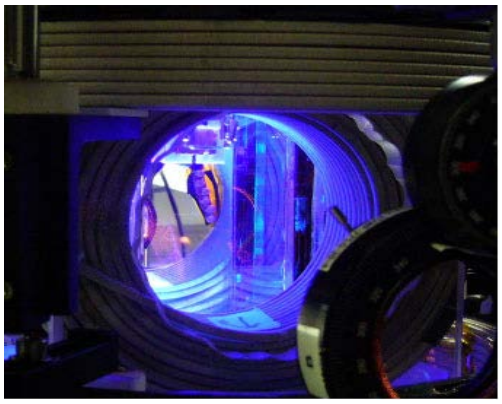
COLD ATOM PHYSICS CONTROLLED BY AN ADWIN SYSTEM

ADwin-Pro Modular Real Time Data Acquisition and Control



CAS DataLoggers provided the data acquisition and control solution for an associate professor of physics at a major university running an experiment producing ultracold quantum gases containing either bosons or fermions. The experiment took place under ultra-high vacuum inside a pyrex glass cell. Researchers collected the atoms in a magneto-optical trap (MOT) which consisted of 6 laser beams for each atomic species and a magnetic trap produced by two external coils with counter propagating current. While the MOT was on, bright purple LEDs caused light-assisted desorption of atoms from the walls of the cell so that they could be captured in the MOT.

After a brief moment of optical molasses (with the lasers on but no magnetic field), the atoms were gently transported vertically about 5 cm to within 200 µm of a magnetic chip trap by changing the shape of the magnetic field with more coils. Current passing through a wire on the chip, along with external coils, was used to tightly trap the atoms. Radio frequency signals passed through another wire on the chip, which changed the shape of the trap and allowed the hottest atoms to escape, thus lowering the average energy of the atoms. This evaporative cooling could produce quantum degenerate gases, either Bose-Einstein condensates or degenerate fermions. To undertake this incredibly demanding application, the physics department needed a modular data acquisition system capable of highly-accurate measurements in real-time and which offered intuitive software with powerful graphing and display capabilities.

The research team installed an ADwin-Pro Modular Real Time Data Acquisition and Control System to provide them with precise timing and deterministic control of the experiment's processes. The ADwin system's analog channels were used to control current in the coils or wires on the chip and the frequencies and amplitudes of the lasers. The analog output was programmed to step, ramp, or follow an S-shaped curve as desired. Easy programming of the ADwin Pro's analog channels provided a simple way to control many devices in the lab. The digital channels were used to open shutters, trigger frequency sources, flip polarity of current sources, and trigger cameras. Several digital channels were also used to serially program frequency sources. Signals from the digital channels went to a digital buffer consisting of optical isolators to prevent ground loops from forming in the system.

The ADwin-Pro data acquisition system came housed in an enclosure with a choice of bench top or rack-mountable models. The system featured up to 480 analog inputs, digital I/Os or a combination of these, and was available in full, half and quarter rack mainframes as well as AC

or DC powered versions. Different I/O boards and expansion modules allowed the ADwin-Pro to be configured as needed for specific uses. Communication with the host PC could be done through either USB or Ethernet. Plug-in boards supported analog and digital I/Os, counter/timers, PWM signal I/Os, thermocouples and RTD's, 5B or MB input modules, serial, CAN, and Fieldbus communication. The ADwin-Pro's high performance onboard DSP processor with its own local memory handled system management, data acquisition, on-line processing and control of outputs. Processing of each measurement could occur immediately after acquisition.

For some experiments, the researchers chose to transfer these cold atoms from the magnetic chip trap to an optical dipole trap – crossed laser beams which caught the atoms as the chip trap was turned off. This purely optical trap gave experimenters the freedom to adjust the external magnetic field as they pleased, giving them the ability to address Feshbach resonances and to tune the interactions between the atoms. To image the atoms at the end of an experiment, the trap was turned off, the cloud expanded, and a pulse of laser light cast a shadow of the atoms onto a CCD camera. From the size, shape and density of the shadow, the team could determine the cloud's physical properties.

The ADwin-Pro's user-friendy software offered the research team powerful capabilities. With ADbasic, users defined the processing sequences being executed on the ADwin hardware. ADbasic optimized and compiled the program code on a simple mouse-click. After being loaded on the ADwin system by ADbasic or a graphical PC user interface, the real-time processes executed independently. ADbasic contained the functions to access all inputs and outputs as well as functions for floating-point operations, process control and communication with the PC. A library was provided which contained standard functions, e.g. for filtering, various examples for counter use, closed-loop controllers, function generators, etc. which led to a faster program implementation.

Every aspect of this experiment required the precise control provided by the ADwin-Pro system. Voltage controlled acousto-optical modulators altered the frequency and amplitude of the laser light, while seven external coils as well as wires on the chip created the magnetic field. The way these magnetic fields switched on and off were important to keep the atoms cold. The team used voltage-controlled power supplies to control the current through these coils and wires. Other equipment including radio and microwave frequency sources, shutters and cameras required well-timed triggers.

By means of the easily configurable ADTools, researchers were able to display the experiment's real-time data graphically or numerically, to visualize process sequencings, or to set input values via potentiometers, sliders or push buttons. Additionally, ADtools constantly provided researchers with the current status of their ADwin system resources. The ADwin software environment could be used under Windows (2000/XP/Vista/Win7) and Linux, or as a stand-alone data acquisition system. Also, ADwin offered drivers for many of the popular programming environments including Visual Basic, Visual C/C++, LabVIEW/LabWindows, TestPoint and others.

The university's physics department benefitted in several important ways following installation of the ADwin-Pro Modular Real Time Data Acquisition and Control System. Using up to 480

analog/digital I/O inputs and high-performance DSP processor, the ADwin-Pro system performed real-time measurements at extremely high accuracy and also performed all the necessary control functions for the experiment. The system's modular design offered researchers the flexibility to configure the cards as desired and to add more hardware as needed. Additionally, ADwin's intuitive ADbasic and ADTools software added visualization, graphing and display features and ensured that the experiment continued uninterrupted with continual status of system resources.

For further information on the ADwin-Pro Modular Real Time Data Acquisition and Control System, other data acquisition devices from ADwin, or to find the ideal solution for your application-specific needs, contact a CAS Data Logger Applications Specialist at (800) 956-4437 or visit the website at www.DataLoggerInc.com.